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HERON LAKE, JACKSON COUNTY, MINNESOTA,
EPA REGION V.

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center

December 1974

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NATIONAL EUTROPHICATION SURVEY

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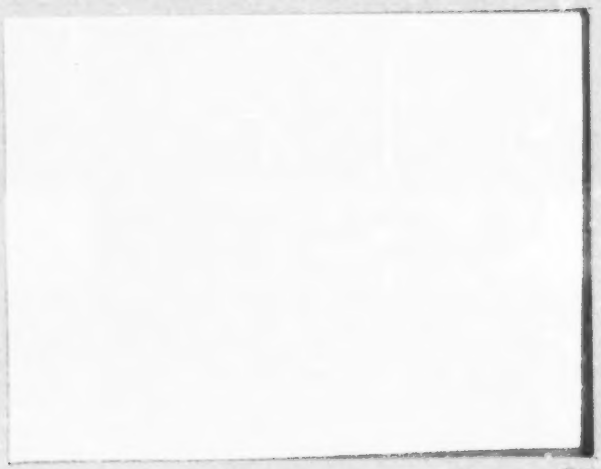

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REPORT

ON

HERON LAKE

JACKSON COUNTY

MINNESOTA

EPA REGION V

WORKING PAPER No. 103

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

DECEMBER, 1974

TECHNICAL REPORT DATA
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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

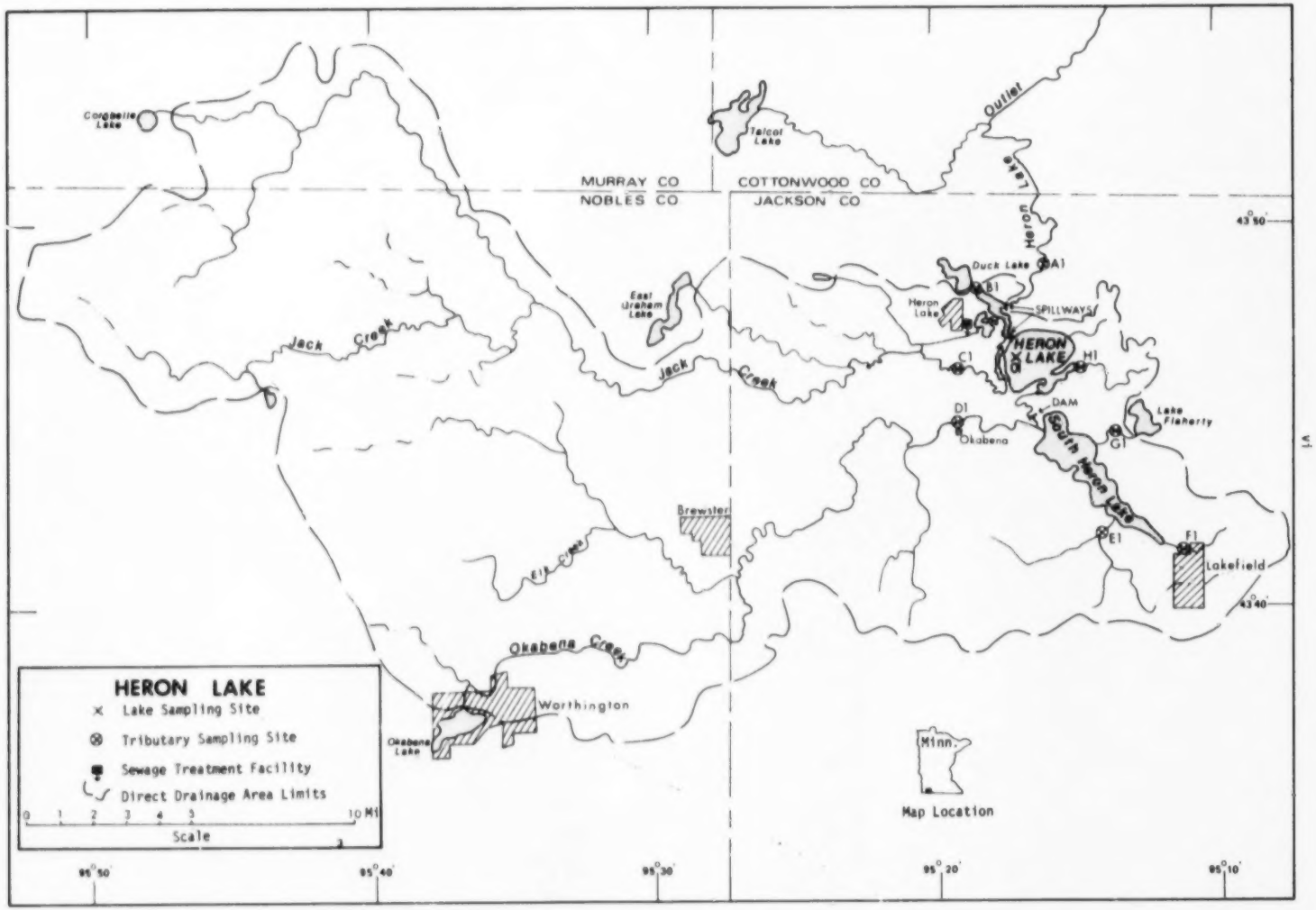
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


MURRAY CO
NOBLES CO
COTTONWOOD CO
JACKSON CO
Outlet
Talcot Lake
Corgelle Lake
Jack Creek
East Graham Lake
Duck Lake
Heron Lake
SPILLWAYS
HERON LAKE
A1
B1
C1
H1
DAM
D1
Okabena
South Heron Lake
Lake Flaherty
G1
E1
F1
Lakefield
Brewster
Elk Creek
Okabena Creek
Worthington
Okabena Lake
43°50'
43°40'
95°50'
95°40'
95°30'
95°20'
95°10'
HERON LAKE
Lake Sampling Site
Tributary Sampling Site
Sewage Treatment Facility
Direct Drainage Area Limits
0 1 2 3 4 5 10 MI
Scale
Minn.
Map Location

HERON LAKE

STORET NO. 2739

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Heron Lake is eutrophic. Of the 80 Minnesota lakes sampled, 58 had less mean total phosphorus, 54 had less mean dissolved phosphorus, 68 had greater Secchi disc transparency, 71 had less mean chlorophyll a, but only five had less mean inorganic nitrogen.

B. Rate-Limiting Nutrient:

The lake data indicate nitrogen limitation during July and August when N/P ratios were about 1/1 at the time of sampling.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Heron Lake received a total phosphorus load at a rate more than three times the rate proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 11). It is calculated that three point sources--Heron Lake, Lakefield, and Worthington--contributed nearly 41% of the total phosphorus load. However, even with a 100% reduction in phosphorus from the point sources, the loading rate would still be more than twice the eutrophic loading rate. With the rich agricultural land in the drainage area, it is not likely that phosphorus reduction at the point sources would result

in a significant improvement in the trophic condition of the lake unless non-point sources can be controlled as well.

2. Non-point sources--The phosphorus exports of the Heron Lake tributaries were somewhat high as compared to unimpacted Minnesota streams studied elsewhere (e.g., the mean phosphorus export of four Big Stone Lake* tributaries was 19 lbs/mi^2/yr).

In all, it is estimated that non-point sources contributed about 60% of the total phosphorus load to Heron Lake during the sampling year.

* Working Paper No. 85.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 8,251 acres.
2. Mean depth: 3 feet.
3. Maximum depth: 5 feet.
4. Volume: 24,753 acre/feet.
5. Mean hydraulic retention time: 135 days.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area*	Mean flow*
Duck Lake outlet	7.6 mi^2	1.3 cfs
Jack Creek	215.0 mi^2	41.3 cfs
Okabena Creek	160.0 mi^2	32.0 cfs
Ditch J-3 (E-1)	28.5 mi^2	5.6 cfs
Unnamed Stream (F-1)	3.6 mi^2	0.7 cfs
Lake Flaherty outlet	7.5 mi^2	1.4 cfs
Teal Lake outlet (H-1)	3.8 mi^2	0.7 cfs
Minor tributaries & immediate drainage -	33.1 mi^2	9.2 cfs
Totals	459.1 mi^2	92.2 cfs

2. Outlet -

Heron Lake outlet	472.0 mi^2**	92.2 cfs

C. Precipitation***:

1. Year of sampling: 25.4 inches.
2. Mean annual: 21.7 inches.

---

† Schilling, 1973; DNR lake survey map (1964).
* Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Heron Lake was sampled twice during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, near-surface samples for physical and chemical parameters were collected at the single station on the lake (see map, page vi). During each visit, a depth-integrated (near bottom to surface) sample was collected for phytoplankton identification and enumeration, and a similar sample was collected for chlorophyll a analysis.

The results obtained are presented in full in Appendix B, and the data are summarized below.

A. Physical and chemical characteristics:

Parameter	Mean Values 1st Sample (07/01/72)	2nd Sample (08/30/72)
Temperature (Cent.)	25.0	22.0
Dissolved oxygen (mg/l)	10.8	8.4
Conductivity (μmhos)	940	875
pH (units)	8.9	9.2
Alkalinity (mg/l)	152	104
Total P (mg/l)	0.366	0.239
Dissolved P (mg/l)	0.204	0.105
NO_2 + NO_3 (mg/l)	0.050	0.060
Ammonia (mg/l)	0.060	0.100
Chlorophyll a (μg/l)	41	181
Secchi disc (inches)	18	6

Parameter	Min. for all samples	Max. for all samples	Mean for all samples
Temperature	22.0	25.0	23.5
Dissolved oxygen	8.4	10.8	9.6
Conductivity	875	940	908
pH	8.9	9.2	9.0
Alkalinity	104	152	128
Total P	0.239	0.366	0.302
Dissolved P	0.105	0.204	0.154
$NO_2 + NO_3$	0.050	0.060	0.055
Ammonia	0.060	0.100	0.080
Chlorophyll a	41	181	111
Secchi disc	6	18	12

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
07/01/72	1. Oscillatoria	13,575
	2. Fragilaria	815
	3. Synedra	317
	4. Navicula	226
	5. Cryptomonas	226
	Other genera	452
	Total	15,611
08/30/72	1. Oscillatoria	7,602
	2. Merismopedia	996
	3. Cryptomonas	362
	4. Cyclotella	362
	5. Flagellates	272
	Other genera	768
	Total	10,362

2. Chlorophyll *a* -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
07/01/72	01	40.9
08/30/72	01	181.2

C. Limiting Nutrient Study:

Heron Lake was not sampled in the fall of 1972 when ordinarily an algal assay sample would have been collected. However, the lake data indicate nitrogen limitation on both sampling visits (N/P ratios were near 2/1).

The potential primary productivity would likely have been high based on the level of nutrients in the lake.

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff months of April and May when two samples were collected. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the means of the nutrient loads, in lbs/mi^2/year, at stations C-1, G-1, and H-1 and multiplying the means by the ZZ area in mi^2. Except for Ditch J-3, the tributary nutrient loads given are those measured minus point sources, if any. The estimated nutrient loads for Lakeland exceeded those measured in Ditch J-3, and the non-point loads for the Ditch were estimated in the same way as the ZZ loads.

The operators of the Heron Lake, Lakefield, and Worthington wastewater treatment plants declined to participate in the Survey, and nutrient loads were estimated at 2.5 lbs P and 7.5 lbs N/capita/year.

* See Working Paper No. 1.

A. Waste Sources:

1. Known municipal† -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Heron Lake	777	stab. ponds	0.078*	Heron Lake
Lakefield	1,820	trickling filter	0.182*	Ditch J-3
Worthington	9,825	trickling filter	0.982*	Ditch J-12 to Okabena Creek

2. Known industrial - None

† Anonymous, 1974.
* Estimated at 100 gal/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Duck Lake outlet	1,010	1.3
Jack Creek	16,210	21.2
Okabena Creek	21,970	28.8
Ditch J-3 (E-1)	1,790	2.3
Unnamed Stream (F-1)	200	0.3
Lake Flaherty outlet	610	0.8
Teal Lake outlet	120	0.2
b. Minor tributaries & immediate drainage (non-point load) -	2,080	2.7
c. Known municipal STP's -		
Heron Lake	1,940	2.5
Lakefield	4,550	6.0
Worthington	24,560	32.2
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	1,290	1.7
Total	76,330	100.0

2. Outputs -

Lake outlet - Heron Lake outlet 49,450

3. Net annual P accumulation - 26,880 pounds

* See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/yr	% of total
a. Tributaries (non-point load) -		
Duck Lake outlet	13,810	1.1
Jack Creek	443,450	36.3
Okabena Creek	438,260	35.9
Ditch J-3 (E-1)	55,000	4.5
Unnamed Stream (F-1)	13,050	1.1
Lake Flaherty outlet	16,190	1.3
Teal Lake outlet	5,960	0.5
b. Minor tributaries & immediate drainage (non-point load) -	63,870	5.2
c. Known municipal STP's -		
Heron Lake	5,830	0.5
Lakefield	13,650	1.1
Worthington	73,690	6.0
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	79,490	6.5
Total	1,222,250	100.0

2. Outputs -

Lake outlet - Heron Lake outlet 753,640

3. Net annual N accumulation - 468,610 pounds

* See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Duck Lake outlet	133	1,817
Jack Creek	75	2,062
Okabena Creek	137	2,739
Unnamed Stream (F-1)	56	3,625
Lake Flaherty outlet	81	812,159
Teal Lake outlet	32	1,568

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	9.3	3.3	148.1	56.8
grams/m^2/yr	1.04	0.37	16.6	6.4

Vollenweider loading rates for phosphorus (g/m^2/yr) based on mean depth and mean hydraulic retention time of Heron Lake:

"Dangerous" (eutrophic rate)	0.30
"Permissible" (oligotrophic rate)	0.15

V. LITERATURE REVIEWED

Anonymous, 1974. Wastewater disposal facilities inventory. MPCA, Minneapolis.

Schilling, Joel, 1973. Personal communication (lake morphometry). MPCA, Minneapolis.

Vollenweider, Richard A., (in press). Input-output models. Schweiz A Hydrol.

VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 2739 HERON LAKE

TOTAL DRAINAGE AREA OF LAKE 472.00

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
2739A1	472.00	9.83	18.13	162.00	239.50	170.00	245.50	106.30	46.40	35.00	34.50	22.60	15.40	92.22
2739B1	7.65	0.07	0.10	1.56	3.17	2.67	4.08	1.81	0.67	0.81	0.50	0.27	0.19	1.33
2739C1	215.00	4.24	7.69	76.00	105.00	76.40	109.00	47.50	20.50	16.00	15.40	9.70	7.11	41.28
2739D1	160.00	3.41	6.14	57.00	77.30	56.70	81.10	36.90	16.30	13.80	11.40	7.05	6.17	32.06
2739E1	28.50	0.62	0.98	11.70	12.60	9.98	14.70	6.87	2.92	3.08	1.96	1.11	1.15	5.65
2739F1	3.57	0.05	0.07	0.98	1.43	1.29	1.92	0.92	0.37	0.48	0.26	0.13	0.13	0.67
2739G1	7.53	0.08	0.12	1.71	3.12	2.67	4.02	1.89	0.75	0.93	0.52	0.28	0.22	1.36
2739H1	3.79	0.05	0.06	1.01	1.52	1.32	2.04	0.98	0.32	0.42	0.24	0.13	0.11	0.68
2739J7	46.00	0.94	1.70	16.30	24.10	17.00	24.20	10.70	4.67	3.50	3.40	2.21	1.45	9.20

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 472.00
SUM OF SUB-DRAINAGE AREAS = 472.04

TOTAL FLOW IN = 1104.56
TOTAL FLOW OUT = 1105.10

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2739A1	10	72	15.30	14	15.00				
	11	72	52.00	4	60.00				
	12	72	30.20	3	39.00				
	1	73	41.90						
	2	73	48.40	4	65.00				
	3	73	432.00	11	389.00				
	4	73	195.00	8	203.00	20	203.00		
	5	73	98.60	4	132.00	19	63.00		
	6	73	76.80	19	80.00				
	7	73	18.20	15	14.00				
	8	73	6.54	19	8.06				
	9	73	5.24	8	3.40				
2739H1	10	72	0.22	14	0.23				
	11	72	0.62	4	0.70				
	12	72	0.47	3	0.50				
	1	73	0.32						
	2	73	0.27	4	0.46				
	3	73	4.13	11	3.70				
	4	73	2.57	8	2.70	20	2.70		
	5	73	1.42	4	2.10	19	1.00		
	6	73	1.35	19	1.30				
	7	73	0.31	15	0.30				
	8	73	0.09	19	0.11				
	9	73	0.12	8	0.09				

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 2739 HERON LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2739C1	10	72	6.78	14	6.60				
	11	72	22.20	4	26.00				
	12	72	13.90	3	18.00	12	16.00		
	1	73	18.00						
	2	73	20.50	4	28.00				
	3	73	201.00	11	181.00				
	4	73	45.00	8	88.00	20	88.00		
	5	73	40.50	4	59.00	19	28.00		
	6	73	14.50	19	35.00				
	7	73	8.08	15	7.70				
	8	73	2.87	19	3.50				
	9	73	2.40	8	1.70				
2739D1	10	72	5.03	14	4.90				
	11	72	16.10	4	19.00				
	12	72	12.00	3	16.00				
	1	73	16.20						
	2	73	16.90	4	23.00				
	3	73	179.00	11	160.00				
	4	73	62.60	8	65.00	20	65.00		
	5	73	38.00	4	44.00	19	21.00		
	6	73	25.80	19	26.00				
	7	73	6.27	15	6.00				
	8	73	2.28	19	2.80				
	9	73	2.07	8	1.50				
2739E1	10	72	0.84	14	0.80				
	11	72	2.54	4	2.90				
	12	72	2.24	3	2.90				
	1	73	2.44						
	2	73	2.39	4	3.20				
	3	73	31.50	11	28.00				
	4	73	10.20	4	11.00	20	11.00		
	5	73	5.29	4	7.70	19	3.70		
	6	73	4.67	19	4.90				
	7	73	1.17	15	1.10				
	8	73	0.41	19	0.50				
	9	73	0.46	8	0.33				
2739F1	10	72	0.11	14	0.10				
	11	72	0.30	4	0.30				
	12	72	0.25	3	0.30	8	0.30		
	1	73	0.21						
	2	73	0.19	4	0.20				
	3	73	2.60	11	2.30				
	4	73	1.15	8	1.20	20	1.20		
	5	73	0.58	4	1.00	19	0.50		
	6	73	0.61	19	0.60				
	7	73	0.16	15	0.15				
	8	73	0.05	19	0.06				
	9	73	0.07	8	0.05				

LAKE CODE 2739 HERON LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2739G1	10	72	0.23	14	0.20				
	11	72	0.64	4	0.70				
	12	72	0.43	3	0.60				
	1	73	0.34						
	2	73	0.32	4	0.40				
	3	73	4.53	11	4.10				
	4	73	2.53	8	2.60	20	2.60		
	5	73	1.42	4	2.10	19	1.50		
	6	73	1.28	19	1.30				
	7	73	0.32	15	0.31				
	8	73	0.11	19	0.13				
	9	73	0.14	8	0.10				
2739H1	10	72	0.11	14	0.10				
	11	72	0.30	4	0.30				
	12	72	0.21	3	0.30				
	1	73	0.21						
	2	73	0.15	4	0.20				
	3	73	2.68	11	2.40				
	4	73	1.23	8	1.30	20	1.30		
	5	73	0.70	4	1.00	19	0.50		
	6	73	0.65	19	0.70				
	7	73	0.15	15	0.14				
	8	73	0.04	19	0.05				
	9	73	0.06	8	0.04				
2739Z7	10	72	1.50	14	1.50				
	11	72	5.06	4	5.80				
	12	72	2.83	3	3.60	8	3.60		
	1	73	4.17						
	2	73	4.52	4	5.10				
	3	73	43.20	11	39.00				
	4	73	19.50	8	20.00	20	20.00		
	5	73	9.01	4	13.00	19	5.30		
	6	73	7.68	19	8.00				
	7	73	1.92	15	1.80				
	8	73	0.65	19	0.70				
	9	73	0.53	8	0.34				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

273901
43 47 00.0 095 17 00.0
HERON LAKE
27063 MINNESOTA

11EPALES
5

2111202
0005 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 N02&N03 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/01	17	30 0000	25.0	10.8	18	940	8.90	152	0.050	0.060	0.366	0.204
72/08/30	18	40 0000	22.0	8.4	6	875	9.14	104	0.060	0.100	0.234	0.105

81

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/01	17	30 0000	40.9J
72/08/30	18	40 0000	181.2J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/03/03

2739A1 LS2739A1
43 49 00.0 095 15 30.0
HERON LAKE OUTLET
27 7.5 HERON LAKE
O/HERON LAKE
ST HWY 60 BRDG BETW HERON LK AND WILDER
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	09 00		0.020	2.015	0.160	0.210	0.330
72/11/04	10 40		0.580	1.800	0.280	0.147	0.220
73/03/11	08 45		1.060	2.940	0.720	0.270	0.430
73/03/23	16 45		2.900	1.980	0.950	0.115	0.250
73/04/08	09 45		3.700	2.600	0.160	0.063	0.230
73/04/20	15 30		3.400	2.300	0.063	0.060	0.210
73/05/04	17 15		2.400	4.300	0.066	0.033	0.221
73/05/19	10 00		1.300	3.100	0.019	0.032	0.210
73/06/19	08 00		0.147	4.100	0.056	0.066	0.410
73/07/15	09 00		0.019	4.200	0.042	0.094	0.400
73/08/19	10 15		0.039	3.300	0.420	0.147	0.195
73/09/06	09 20		0.250	3.990	0.470	0.168	0.470

STORET RETRIEVAL DATE 75/03/03

273981 LS273981
43 48 30.0 095 18 00.0
DUCK LK OUTLET TO HERON LK
27 7.5 HERON LAKE
T/HERON LAKE
ST HWY 60 BRDG .75 MI NE OFHERON LAKE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	09	30	0.087	7.875	0.410	0.060	0.157
72/11/04	10	50	0.360	2.900	0.770	0.075	0.147
73/03/11	08	30	0.910	2.600	0.435	0.655	0.810
73/03/23	15	30	0.110	2.100	0.093	0.020	0.165
73/04/08	10	00	0.024	3.150	0.147	0.022	0.170
73/04/20	15	45	0.048	2.600	0.027	0.028	0.165
73/05/04	17	25	0.126	2.400	0.024	0.031	0.160
73/05/19	09	30	0.012	2.200	0.044	0.026	0.160
73/06/19	08	15	0.028	6.400	0.126	0.115	0.490
73/07/15	09	15	0.010K	20.500	7.800	0.420	1.650

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/03/03

2739C1 LS2739C1
43 46 00.0 095 19 00.0
JACK CREEK
27 7.5 HERON LAKE
T/HERON LAKE
CO HWY 9 BRDG 1.5 MI S OF HERON LAKE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	09	40	0.030	1.675	0.075	0.011	0.190
72/11/04	10	50	5.500	3.200	0.270	0.240	0.610
72/12/12	08	15	7.500	0.330	0.066	0.052	0.093
73/03/11	09	20	1.400	2.300	0.560	0.230	0.375
73/03/23	16	15	3.700	1.890	0.138	0.079	0.230
73/04/08	09	30	5.000	2.000	0.069	0.042	0.170
73/05/04	17	40	6.200	1.500	0.006	0.015	0.070
73/05/19	09	15	5.800	2.300	0.075	0.015	0.110
73/06/19	08	30	5.800	1.400	0.047	0.057	0.240
73/07/15	09	30	0.550	1.800	0.092	0.027	0.220
73/08/19	09	45	0.030	3.100	0.067	0.066	0.080

STORET RETRIEVAL DATE 75/03/03

273901 LS273901
43 45 00.0 095 19 00.0
OKABENA CREEK
27 CO # 32
T/HERON LAKE
CO HWY 9 BRDG N EDGE OF OKABENA
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	10 00		0.220	5.075	0.336	0.360	0.630
72/11/04	11 00		4.200	4.200	0.780	0.610	1.040
73/03/11	09 10		2.500	2.520	1.260	0.470	0.575
73/03/23	16 00		7.700	1.380	0.590	0.350	0.430
73/04/08	09 20		8.900	4.100	3.400	0.650	0.760
73/04/20	16 15		10.000	2.310	0.730	0.300	0.440
73/05/04	17 50		10.300	2.800	0.590	0.320	0.450
73/05/19	10 15		7.300	3.780	0.022	0.198	0.490
73/06/19	08 45		7.500	1.950	0.176	0.430	0.680
73/07/15	09 45		2.400	4.600	0.050	0.310	0.795
73/08/19	09 30		0.240	1.200	0.390	0.750	1.500
73/09/08	08 40		0.380	6.900	0.760	0.992	1.880

STORET RETRIEVAL DATE 75/03/03

2739E1 LS2739E1
43 41 30.0 095 13 30.0
UNNAMED TRIB TO S PART S HERON L
27 CO #32
T/HERON LAKE
CO HWY 20 BRDG 2.5 MI WNW OF LAKEFIELD
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	10 05		0.450	2.475	0.320	0.126	0.294
72/11/04	11 10		8.300	0.980	0.132	0.200	0.390
73/03/11	08 55		4.200	3.700	0.660	0.357	0.510
73/03/23	15 45		10.200	2.200	0.005K	0.096	0.130
73/04/08	09 05		12.400	1.100	0.105	0.037	0.090
73/04/20	16 30		12.000		0.008	0.031	0.040
73/05/04	18 00		13.000	0.500	0.026	0.034	0.070
73/05/14	10 30		14.400	1.000	0.088	0.031	0.113
73/06/19	09 00		14.700	1.380	0.154	0.160	0.290
73/07/15	10 00		8.300	1.260	0.115	0.095	0.155
73/08/19	09 15		4.900	1.130	0.180	0.200	0.280

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/03/03

2739F1 LS2739F1
43 41 00.0 095 10 30.0
UNNAMED TRIB TO SE END S HERON L
27 CO # 32
T/HERON LAKE
ST HWY 86 XING N EDGE OF LAKEFIELD
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	10	15	2.000	0.580	0.049	0.082	0.105
72/11/04	11	15	8.900	0.100K	0.007	0.092	0.115
72/12/08	08	10	10.400	0.700	0.017	0.096	0.210
73/03/11	08	10	5.900	3.500	0.650	0.400	0.590
73/03/23	17	30	10.200	0.420	0.005K	0.115	0.130
73/04/08	09	00	12.000	0.310	0.018	0.057	0.065
73/04/20	16	45	12.000	0.760	0.018	0.052	0.055
73/05/04	16	40	12.600	0.240	0.005K	0.050	0.065
73/05/19	09	45	11.200	0.300	0.020	0.050	0.065
73/06/19	09	15	17.000	1.470	0.054	0.105	0.175
73/07/15	10	15	12.000	0.150	0.021	0.115	0.135
73/08/19	09	00	7.400	2.000	0.178	0.105	0.125
73/09/08	08	00	2.200	1.340	0.138	0.280	0.320

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/03/03

2739G1 LS2739G1
43 44 30.0 095 13 00.0
LK FLAHERTY/S HERON LK CONNECTIO
27 CO #32
T/HERON LAKE
CO HWY 24 XING .5 M W OF LKFLAHERTY
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	10	30	0.070	2.800	0.170	0.016	0.240
72/11/04	11	25	1.400	1.600	0.394	0.138	0.260
73/02/04	08	20	0.294	4.000	1.300	0.005K	0.075
73/03/11	08	30	0.480	1.980	0.520	0.037	0.150
73/03/23	17	00	0.740	8.700	0.138	0.019	0.160
73/04/08	09	15	0.950	3.800	0.050	0.031	0.160
73/04/20	17	00	1.000	3.650	0.105	0.050	0.190
73/05/04	16	55	0.730		0.150	0.044	0.190
73/05/19	08	45	2.600	3.100	0.710	0.048	0.330
73/06/19	09	30	7.000	2.800	0.370	0.036	0.142
73/07/15	10	30	0.019	11.000	4.500	0.160	0.760
73/08/19	10	30	0.078	13.000	4.625	0.105	0.185
73/09/08	09	40	2.000	3.900	1.000	0.260	0.490

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/03/03

2739M1 LS2739M1
43 46 00.0 095 14 30.0
TEAL LAKE/HERON LAKE CONNECTION
27 CO #32
T/HERON LAKE
CO HWY 24 AING .5 MI E OF HERON LAKE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	10 45		0.104	1.325	0.100	0.015	0.170
72/12/03	08 00		0.273	2.000	0.480	0.005K	0.033
73/03/11	08 50		2.200	2.500	0.450	0.210	0.345
73/03/23	17 15		3.800	3.300	0.005K	0.030	0.060
73/04/08	09 30		5.960	1.750	0.115	0.014	0.030
73/04/20	17 15		5.800	0.920	0.042	0.014	0.025
73/05/04	17 00		5.800	0.950	0.022	0.014	0.040
73/05/14	09 00		2.600	3.100	0.130	0.015	0.050
73/06/14	09 45		5.400	0.585	0.048	0.030	0.065
73/07/15	10 45		0.080	1.380	0.113	0.025	0.145
73/08/19	10 30		0.065	1.600	0.120	0.120	0.125

K VALUE KNOWN TO BE
LESS THAN INDICATED